Model # 91550-2
S/N 12057

TEGAM

INSTRUCTION MANUAL
FOR
CURRENT PROBE
MODEL NO. 91550-2

MANUAL NO. 1-500783-209

Serial No. 12057

Reprinted 1/83 Lib

THE GLOBAL SOURCE FOR PROVEN TEST & MEASUREMENT TECHNOLOGY

TEGAM

TEN TEGAM WAY · GENEVA, OHIO 44041
PHONE 216-466-6100 · FAX 216-466-6110

WARRANTY

Tegam, Inc. (SELLER) warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

Electrical and Electronic Measuring Instrument...1 Year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and Ratio Tran potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other warranties, express or implied INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY, or fitness for a particular purpose. In no event shall the SELLER be liable for INCIDENTAL OR CONSEQUENTIAL damages. The SELLER neither assumes, nor authorizes any person to assume for it, any other liability in connection with sales of instruments manufactured by SELLER.

With respect to repairs, the foregoing warranty shall apply for a period of ninety days to the repaired portion.

REPAIRS AND MAINTENANCE

Instruments should be returned only on prior authorization from the representative or the factory. You will be advised of detailed shipping instructions at that time. Return the instrument to the factory prepaid. Validity of warranty shall be determined by the factory.

Chargeable repairs: If requested, an estimate of charges will be made prior to repairs. Please provide us with the following information in order to expedite the processing of your instruments:

1. Model or Type
2. Serial Number
3. Description of trouble*
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Maintenance action previously requested
7. Other comments

* Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken and any other relevant data.

CONTENTS

Section			Page
I	GENERAL DESCRIPTION AND THEORY OF OPERATION		
	1.1	General Information	1-1
	1.1.1	Application	1-1
	1.2	Electrical Characteristics	1-2
	1.3	Mechanical Characteristics	1-2
	1.4	General Theory of Operation	1-2
	1.4.1	Circuit	1-3
	1.4.2	Sensitivity	1-3
	1.4.3	Core Saturation	1-4
	1.4.4	Transfer Impedance	1-4
II	INSTALLATION		
	2.1	Introduction	2-1
	2.2	Equipment Setup	2-1
	2.2.1	General	2-1
	2.2.2	Current Probe Installation	2-2
	2.3	Precautionary Measures	2-3
III	OPERATION		
	3.1	Introduction	3-1
	3.2	Equipment Set up	3-1
	3.3	Signal Measurement	3-1
	3.3.1	Oscilloscope Use	3-1
	3.3.2	RFI Equipment Use	3-2
	3.3.2.1	In Terms of dB above One Microampere (Narrowhead CW Conducted Measurement)	3-2
	3.3.2.2	In Terms of dB above One Microampere-Per-Megahertz (Broadband Interference Measurement)	3-2
	3.3.2.3	In Terms Microamperes in Test Sample Lead (Narrowhead CW Conducted Measurement)	3-3
	3.3.2.4	In Terms Microamperes-Per-Megahertz in Test Sample Lead (Broadband Interference Measurement)	3-4

ILLUSTRATIONS

Figure

1. Current Probe Transfer Impedance - Decibels Reference to One Ohm

2. Current Probe Transfer Impedance - Ohms

Section I

GENERAL DESCRIPTION AND THEORY OF OPERATION

1.1 GENERAL INFORMATION

The Model No. 91550-2 current probe is a "clamp-on" type RF current transformer. It is an accessory device used with a calibrated EMI/RFI equipment, oscilloscope, or other voltage sensitive instrument to determine the intensity of radio frequency current present in an electrical conductor, or group of conductors.

Direct connection to a conductor is not required. The current probe is simply clamped around the test conductor that becomes a one turn primary winding. The clamp-on feature of this probe enables easy placement around any conductor or cable up to 1-1/4 inches in diameter.

The Model 91550-2 current probe is internally loaded to provide a substantially constant transfer impedance of one ohm within $\pm$ 2 dB from 100 kHz to 150 MHz, see Figure 1.

1.1.1 Application

Normal signal current range for this probe is 0 to 100 amperes which provides up to 100 V across a 50 ohm load. Because of limited power handling capability of the current probe's secondary circuit (internal loading and wire size), the maximum pulse duty cycle at 100 amperes peak is 0.001.

The constancy of transfer impedance with frequency is a direct measure of the frequency response of the current probe. As indicated by the transfer impedance curve of Figure 1, the high frequency response is commensurate with that of an oscilloscope with a bandwidth of over 100 megahertz. Also, the current probe core is designed so that RF pulse currents in excess of 100 amperes can be easily accommodated without core saturation.

1.2 ELECTRICAL CHARACTERISTICS

a)	Circuit	Current Transformer, Inserted Primary Type
b)	Frequency Range	0.010-150 MHz.
c)	Transfer Impedance	1.0 ohm nominal
d)	Maximum Signal Current:	
	1) Continuous (CW):	2.8 amperes
	2) Pulse:	100 amperes with following maximum duty cycle,

Ip Amp	Max. Duty Cycle
10.0	0.080
30.0	0.010
50.0	0.003
100.0	0.001

e)	Maximum Power Current	350 amperes dc to 60 Hertz, 225 amperes at 400 Hertz
f)	Maximum Power Voltage	No limitation, subject to adequate conductor insulation.
g)	Rated Output Load Impedance	50 $\pm$ j0 ohms.
h)	Sensitivity Under Rated Load	1.0 Microamperes with 1 microvolt sensitivity receiver and 1 ohm transfer impedance.
i)	Output Connector	Type UG-58A/U, "Type N"

1.3 MECHANICAL CHARACTERISTICS

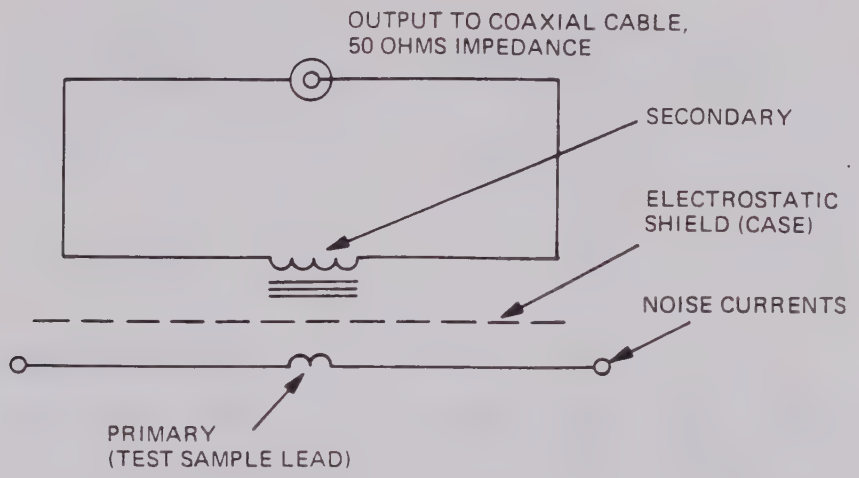
a)	Window Size	1.25 inches diameter
b)	Overall Dimensions	3-1/2" long x 2-7/8" wide x 1-3/8" thick.

1.4 GENERAL THEORY OF OPERATION

The RF Current Probe, Model 91550-2, is an inserted primary type of radio frequency current transformer. When the probe is clamped over the conductor or cable in which current is to be measured, the conductor forms the primary winding.

1.4.1 Circuit:

The circuit is that of a radio frequency transformer as illustrated below:



Since the Current Probe is intended for "clamp on" operation, the primary shown in the foregoing drawing is actually the electrical conductor in which interference currents are to be measured. This primary is considered as one turn since it is assumed that the RF signal currents flow through the conductor and return to the source via a "ground" conductor such as a frame, common ground plane, or the earth.

1.4.2 Sensitivity

The 91550-2 current probe has a moderate sensitivity, being designed for large RF signals and for operation directly into an oscilloscope across a 50 ohm load. Typically the current probe output per ampere of RF signal current varies from 0.8 to 1.2 volts from 100 kHz to 100 MHz across a 50 ohm load, see paragraph 1.4.4 and Figure 2. However, should the 91550-2 current probe be used with a calibrated receiver or EMI measuring equipment then the probe sensitivity in microamperes is dependent on the microvolt sensitivity of

the receiving instrument. The following table shows the relationship of receiver sensitivity in microvolts to overall sensitivity of probe and receiver in micro-amperes. This data is based on a transfer impedance of 1.0 ohms, again refer to Paragraph 1.4.4.

Radio Interference and Field Intensity Equipment Sensitivity in Microvolts	Overall Sensitivity of Probe and Receiver in μA
4	4
2	2
1	1
0.1	0.1

1.4.3 Core Saturation

The current probe will not saturate at RF signal currents below 100 amperes in the primary or test conductor. However, the pulse duty cycle of 0.001 at a RF signal level of 100 amperes should not be exceeded or the current probe internal load resistor will be subject to damage. Also, this resistor must be protected from 60 hertz power line currents in excess of 350 amperes and 400 hertz power line currents in excess of 225 amperes.

1.4.4 Transfer Impedance

The RF current (I_p) in the conductor under test is determined from the Radio Interference and Field Intensity meter reading of the current probe output in microvolts (E_s) divided by the current probe transfer impedance (Z_T), or,

$$I_p = \frac{E_s}{Z_T}$$

The transfer impedance in ohms of the current probe throughout the frequency range is shown in Figure 2. It is determined by passing a known RF current I_p through the primary test conductor and noting the voltage E_s developed across a 50 ohm load. Then,

$$Z_T = \frac{E_s}{I_p}$$

SECTION II

INSTALLATION

2.1 INTRODUCTION

This section outlines procedures for setting up the current probe and associated measuring equipment. Operating procedures are contained in Section III.

2.2 EQUIPMENT SETUP

2.2.1 General

In measuring the RF current in a single conductor, the probe jaws are placed around the conductor and locked together. In the case of a two-conductor cable, the probe can be used to evaluate the longitudinal component of the noise current (the net effect of the currents leaving the returning) by placing the probe over both conductors at the same time, or the interference current in either conductor can be measured separately by placing the probe over each wire individually.

In the more complex case of multi-conductor cables, the probe will measure the net external effects of all the currents in the conductors.

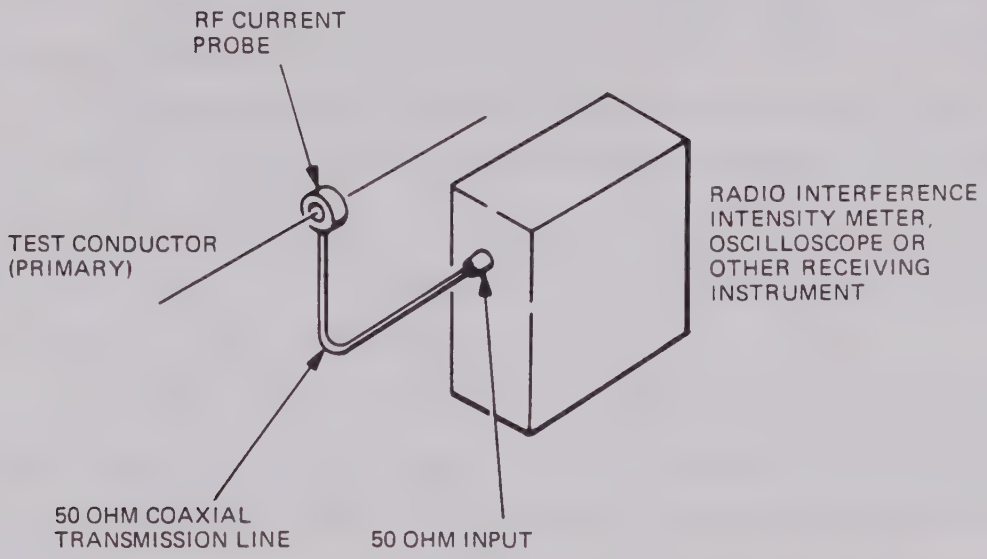
When placed over shielding conduit, coaxial cable, or ignition shielding, the probe measures the current flowing on the external surface of the shield. The probe can thus be used to evaluate the shielding effectiveness.

NOTE

Standing waves can exist on the test conductor at or near its resonant frequency. Under these conditions, several measurements taken along the line will provide a complete picture of the RF current distribution and amplitude. A "grid-dip" oscillator can sometimes be used to determine the conductor resonant frequency.

2.2.2 Current Probe Installation:

A typical current probe installation is shown below:


RF CURRENT PROBE
TEST CONDUCTOR (PRIMARY)
RADIO INTERFERENCE INTENSITY METER, OSCILLOSCOPE OR OTHER RECEIVING INSTRUMENT
50 OHM COAXIAL TRANSMISSION LINE
50 OHM INPUT

The window of the probe will accommodate the following cables:

(a) Single conductors up to a maximum size of AN 4/0 aircraft cable.

(b) Bundles of cables up to a maximum outside diameter of 1.25 inches.

(c) Flexible coaxial cable and shielded conduits up to a maximum outside diameter of 1.25 inches.

After placing the probe over the conductors to be measured, the probe jaws should be carefully locked with the latching clamp. If this is not done, inadequate shielding or incorrect air gap will result and the meter readings will not be accurate.

The connecting cable used between the current probe and the radio interference and field intensity equipment or other receiving or display device must have a 50 ohm characteristic impedance and matching cable connectors.

The usual precautions regarding minimum bending radius should be observed when installing and using the cable.

The current probe is calibrated for use with a 50 ohm load. Therefore, to maintain the current probe transfer impedance as shown in Figures 1 and 2, the radio interference measuring equipment, oscilloscope or other receiving instrument used must have a 50 ohm input impedance. If a high input impedance device such as an oscilloscope is used, then shunt the input with a 50 ohm resistor of appropriate wattage.

The probe rejection of external pickup from conductors not passing through the window is better than 60 dB. The presence of very strong magnetic fields will, however, have some effect on probe sensitivity. Care must be taken not to place the unit close to permanent magnets or the field structures of motors and generators.

For greatest accuracy, the conductor under measurement should be centered in the window of the current probe.

2.3 PRECAUTIONARY MEASURES

When measuring uninsulated conductors use extreme care when installing the current probe and taking measurements. If possible, de-energize the test sample during assembly and disassembly of the setup. Also, arrange to center the test conductor in the current probe window for additional voltage breakdown protection.

Do not permit the uninsulated current probe connector and cable connectors to come in contact with the ground plane or other nearby conductors. This will prevent possible measurement error due to ground loops, and will avoid danger from high voltages.

SECTION III

OPERATION

3.1 INTRODUCTION

The RF Current Probe is a broadband RF transformer for use with Radio Interference Measuring equipment. Radio frequency currents can be measured in cables without physically disturbing the circuit.

3.2 EQUIPMENT SET-UP

Instructions for clamping the current probe over the test conductor and for connecting the probe to the Radio Interference Measuring equipment are given in Section II, Installation.

3.3 SIGNAL MEASUREMENT

3.3.1 Oscilloscope Use - In terms of RF amperes.

a. PROCEDURE

(1) Standardize the gain of the oscilloscope to read correctly the voltage (E_s) applied to its input terminals.

(2) Divide E_s in volts by the average current probe transfer impedance Z_T in ohms. The result is the value of the RF signal in terms of amperes in the test conductor.

b. EXAMPLE

Assume an oscilloscope peak voltage measurement of 5 volts and the average Z_T to be 1.06 ohms. Then:

5/1.06 = 4.71 amperes in the test conductor

c. COMMENT

The example is valid providing that the oscilloscope rise time ($T = \frac{0.3}{BW}$) is shorter than the RF signal pulse duration.

This also applies to the current probe which has a rise time of about 3 nanoseconds based on a 100 megahertz bandwidth.

3.3.2 RFI EQUIPMENT USE

3.3.2.1 In Terms of dB above One Microampere (Narrowband CW Conducted Measurement)

a. PROCEDURE

(1) Adjust the RI-FI Meter for standard gain and make a measurement of the CW signal (voltage output from the current probe) in terms of dB above one microvolt. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Subtract the Transfer Impedance of the current probe in dB at the test frequency, (see Figure 1) from the dB measurement of Step (1). The result is the value of the conducted CW signal in terms of dB above one microampere in the test conductor.

b. EXAMPLE

Frequency	0.1 Megahertz
Step (1) Measurement	42 dB above one microvolt

For example, suppose that the transfer impedance of the current probe is -1.3 dB above one ohm at 0.1 MHz. Then, as outlined in step (2); 42 dB - (-1.3 dB) = 43.3 dB above one microampere in the test conductor.

3.3.2.2 In Terms of dB above One Microampere-Per-Megahertz (Broadband Interference Measurement)

a. PROCEDURE

(1) Adjust the RI-FI Meter for standard gain and make the Peak measurement of the broadband

interference (voltage output from the current probe) in terms of dB above one microvolt-per-megahertz. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Subtract (algebraically) the Transfer Impedance of the current probe in dB at the test frequency (see Figure 1), from the dB measurement of Step (1). The result is the value of the broadband interference in terms of dB above one microampere-per-megahertz in the test conductor.

b. EXAMPLE

Frequency	10 Megahertz
Step (1) Measurement	30 dB above one microvolt-per-megahertz

For example, suppose that the transfer impedance of the current probe is +1.5 dB above one ohm at 10 megahertz. Then, as outlined in step (2): 30 dB - 1.5 dB = 28.5 dB above one microampere-per-megahertz in the test conductor.

3.3.233 In Terms of Microamperes in Test Sample Lead - (Narrowband CW Conducted Measurement)

a. PROCEDURE

(1) Adjust the RI-FI Meter for standard gain and make a measurement of the CW signal (voltage output from current probe) in terms of microvolts at meter input. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Divide the microvolt measurement of Step (1) by the transfer impedance from Figure 2 in ohms at the test frequency. The result is the value of

conducted CW signal in terms of microamperes in the test conductor.

b. EXAMPLE

Frequency	90 Megahertz
Step (1) Measurement	300 Microvolts

For example, suppose that the transfer impedance of the current probe is 1.3 ohms at 90 Megahertz. Then, as outlined in Step (2), $\frac{300}{1.3}$ = 230.7 microamperes in the test conductor.

3.3.2.4 In Terms of Microamperes-Per-Megahertz in Test Sample Lead - (Broadband Interference Measurement)

a. PROCEDURE

(1) Adjust the RI-FI meter for standard gain and make a measurement of the broadband interference (voltage output from current probe), in terms of microvolts-per-megahertz at meter input. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Divide the microvolt-per-megahertz measurement of step (1) by the transfer impedance from Figure 2 in ohms at the test frequency. The result is the value of conducted broadband interference in terms of microamperes-per-megahertz in the test conductor.

b. EXAMPLE

Frequency	0.5 Megahertz
Step (1) Measurement	75 microvolts-per-megahertz

For example, suppose that the transfer impedance of the current probe is 1.0 ohm at 0.5 megahertz. Then, as outlined in step (2), $\frac{75}{1.0}$ = 75 microamperes-per-megahertz in the test conductor.

Calibration Engineer: ERIC BOWSER
Date: 22 Jan 1996

Serial No.: 12057
Model Type: 91550-2

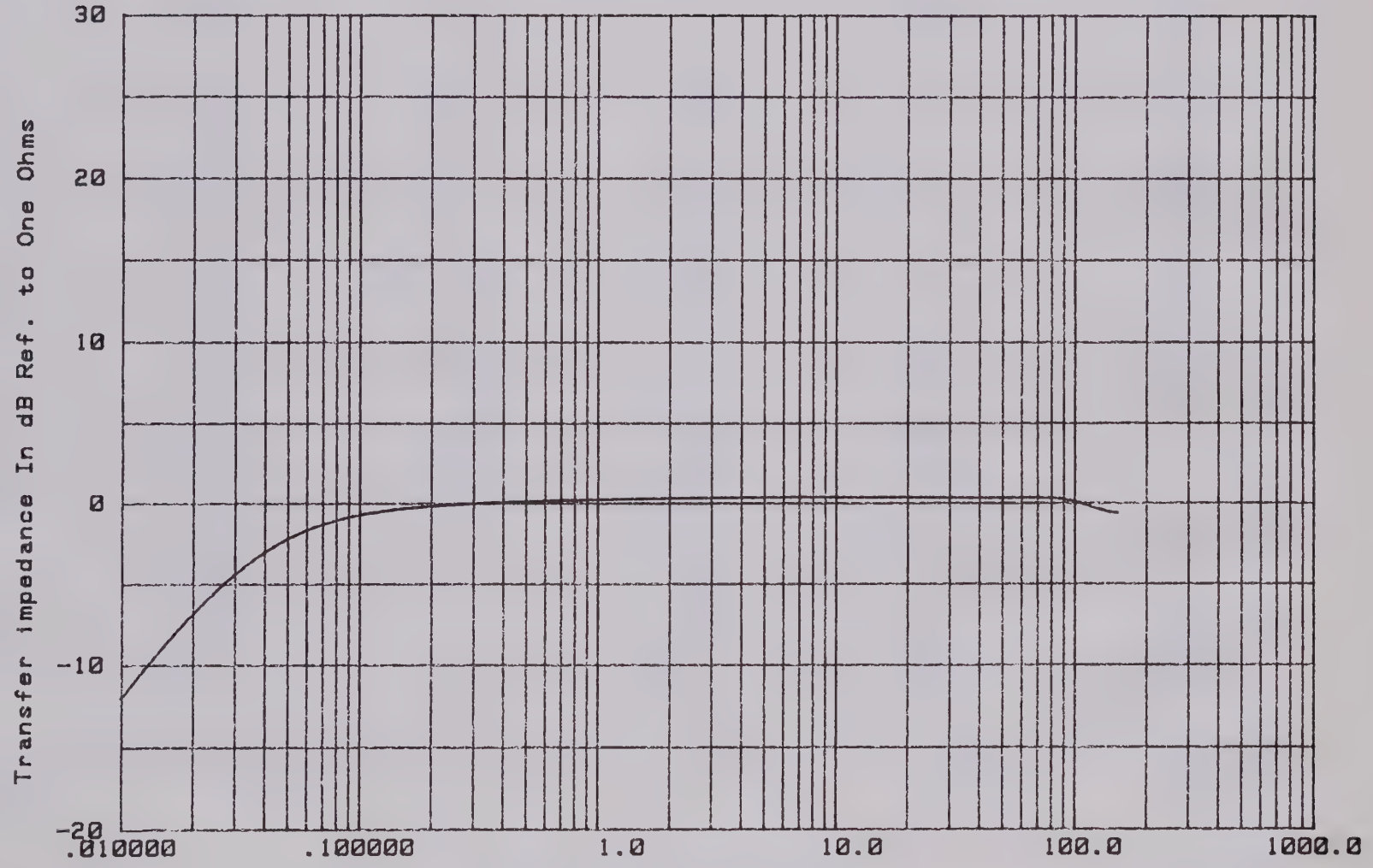


FIGURE 1

Calibration Engineer: ERIC BOWSER
Date: 22 Jan 1996

Serial No.: 12057
Model Type: 91550-2

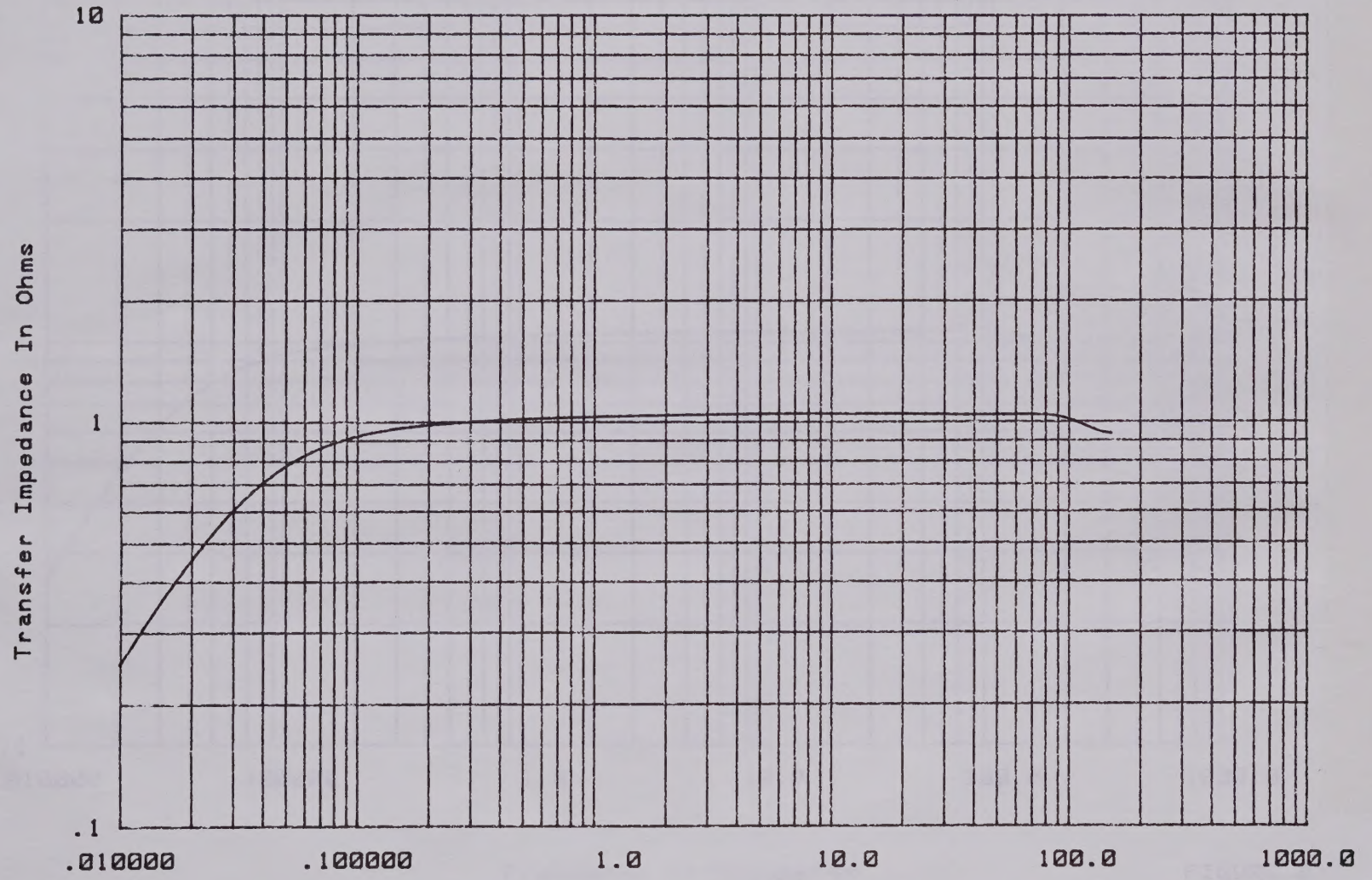
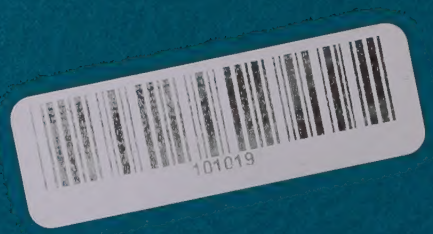


FIGURE 2


101019